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ALLUVIAL QUARTZITE PEBBLES AS A SOURCE OF INDUSTRIAL SILICA

by

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ALLUVIAL QUARTZITE PEBBLES AS A SOURCE OF INDUSTRIAL SILICA

Abstract

Size and lithologic analyses of samples of alluvial sediments from present-day rivers in Alberta show that highly quartzitic gravels are present in long stretches of some rivers in the western parts of the Plains some distance east of the Foothills. Size analyses and concentrations of quartzite in 45 of the samples highest in quartzite are presented. Partial chemical analyses of fractions of some of these samples and petrographic descriptions of the quartzite pebbles indicate that the quartzites in some of these gravels are a potential source of industrial silica for smelter flux, ferrosilicon, and silica brick, uses which do not require quartzite of the highest purity.

INTRODUCTION

Quartzite has a variety of industrial uses, some requiring high purity silica such as the manufacture of glass or silicon carbide, others not so stringent specifications, such as smelter flux. In many places in North America, quartzite that meets the specifications for a particular use is quarried from bedrock. Although thick quartzite formations are known in Lower Cambrian strata, and one in Ordovician strata in the Rocky Mountains of Alberta, most are in National Parks where mining or quarrying is not permitted by current regulations or in places where access is difficult; they are more than two hundred miles from the larger cities in Alberta. During an investigation of sediments in present-day rivers in Alberta, high percentages of quartzite pebbles were found in the gravels in parts of certain rivers. This report presents data on the composition of some of these highly quartzitic gravels. Although no quartzite is currently used for its silica content in Alberta, the quartzites in some of these gravels are a potential source of silica for uses having the less stringent specifications.

SPECIFICATIONS FOR INDUSTRIAL QUARTZITE

The specifications for quartzite vary with the use and even with the user. The specifications included here are restricted to those that may be applicable to the alluvial quartzite pebbles in Alberta, and are mostly those given by Hewitt (1951). They do not include specifications for aggregates.

Silica Flux

The requirement of siliceous material used for flux in smelting base metal ores is its silica content. Silica is the active slagging ingredient, but impurities such as iron, alumina, and bases are not objectionable except that they reduce the percentage of silica available. Therefore, if lower grade silica is available, it may be more economical to use it in preference to more expensive high-purity silica. Lump sizes are usually required. Elements such as lead, arsenic, antimony, bismuth, nickel, cobalt, and tin as trace constituents are deleterious for some uses of silica flux.

Ferrosilicon

Lumps 3/4 inch to 5 inches in size with silica greater than 97.5 per cent, alumina less than 1.0 per cent, iron plus alumina less than 1.5 per cent, MgO and CaO each less than 0.2 per cent, are required. Phosphorus and arsenic are objectionable.

Silica Brick

The raw material for silica brick used as a refractory should contain 96 to 98 per cent or more SiO_2, less than 1.0 per cent alumina, less than 1.0 per cent iron oxides, less than 1.5 per cent combined iron and alumina, and be low in alkalis, magnesium, and lime. Size speicifications require more than 50 per cent between 4 and 28 mesh.

DISTRIBUTION AND EXTENT OF RIVER GRAVELS

Most of the larger rivers in Alberta rise in the mountains along the Continental Divide or east of them in the Foothills. They carry gravel from their sources for up to several hundred miles eastwards or northeastwards across the Plains, before their beds become sandy. A few have sandy beds for tens of miles followed downstream by more gravel and then finally by sand to their mouths or as far downstream as they were examined. In the mountains pebbles and cobbles in the gravels consist mostly of limestone, dolomite, and quartzite from the local bedrock, other constituents such as sandstone, siltstone, shale, and coal being rapidly crushed and abraided to sand size and smaller material. Farther east pebbles of granite and gneiss from the glacial surficial deposits are added in increasing amounts to those already present. These have their source in the Precambrian Shield to the northeast. Also added from preglacial and galcial deposits are pebbles of quartzite and arkose.

Throughout much of Alberta, the rivers flow in deep valleys only a few feet above bedrock, mostly in postglacial valleys, but with some sections in preglacial valleys. Terraces forming parts of the present-day floodplains may contain gravel to a thickness about equal to the depth of water in the river, that is up to about 10 or 12 feet. Higher terraces also may be partly or completely underlain by gravel. The width of the valley which includes the widths of the river and its adjacent terraces depends partly on the length of time the river has flowed in it: preglacial valleys are generally wide and may contain extensive terraces and flats underlain by gravel; postglacial valleys are narrower. Thus, although the width of the valley gives an indication of the lateral extent of the gravel, its actual presence at any place away from exposures must be confirmed by drilling or digging a pit.

Gravels from preglacial and interglacial streams are similar to those of the present-day rivers except that the former do not contain granite and gneiss from the Shield: they are known stratigraphically as Saskatchewan Gravels (Stalker, 1968). Some contain quartzite pebbles of equal or higher percentages of silica than those described in this report. In places the present-day rivers flow in preglacial valleys. Other preglacial valleys have been buried under glacial deposits. The drainage history from preglacial times through the glacial periods to the present day is complex. Data and interpretations have been published by several authors including Gravenor and Bayrock (1961), Stalker (1961 and 1968), Farvolden (1963), Geiger (1965), Carlson (1966), and Gabert and Roed (1968).

Sampling of Gravels

The samples from which the data presented in this report were obtained were collected during a large project on the composition of alluvial sediments in Alberta. The samples were collected systematically where convenient along each of the rivers studied (Fig. 1). The coarsest gravel at any place was selected for sampling, and the places sampled were the top foot or so of the river beds as far from the bank as possible at low water: in general, at the upstream end of island bars, at the middle of point bars, and in straight stretches, in order of decreasing preference. Some samples were collected at more than one of these types of places or other types of places such as the sides of island bars in the same general locality. The detailed locations of the samples for which analyses are presented in this report are given in Appendix I. The sample numbers for each river increase as that river is ascended; the samples are listed in the same order.

At sample locations along most of the rivers, the coarser fractions of gravel samples ranging in volume from 1.0 to 8.0 cubic feet (depending on the coarseness) were sieved and sorted into several lithologic types in the field. Parts of the finer fractions were sieved and sorted lithologically in the laboratory. Data for samples from the Athabasca and Peace Rivers, the upper part of the Bow River, and one place on the Smoky River were obtained from smaller samples of about 40 pounds in the laboratory and so can be expected to be less precise than those from other rivers. At many of the sample sites, the dimensions, weight, and lithology of the largest pebbles, cobbles, or boulders within 30 feet or so of the place sampled were recorded. At some sample locations, cobbles or boulders which were judged to have reached their present positions by means other than movement by water flowing in the river were not included.

Distribution of Highly Quartzitic Gravels

Data on the distribution of quartzite from the screen and lithological analyses of the samples of alluvial gravels are shown in Figure 1. It is apparent from Figure 1 that, in general, the gravels with the highest contents of quartzite in the bed of any one river are present in the western part of the Plains, some distance east of the Foothills. This geographic relation can be explained by the locations of the sources of the pebbles and cobbles now in the gravel, the relative resistance to abrasion of the different lithological types of pebbles and cobbles, and possibly by the sorting action of the water flowing in the rivers. Although a detailed analysis of these factors is beyond the scope of this paper, the data obtained indicate that most alluvial gravels in the Rocky Mountains of Alberta contain a high percentage of limestone and dolomite pebbles which decrease in amount downstream relative to quartzite. This can be explained by their lesser resistance to abrasion. Farther downstream, pebbles of granites and gneisses from the Precambrian Shield and pebbles of carbonate rocks from the Paleozoic strata adjacent to it comprise a significant amount of the gravel. The differences between the three types of sample sites — island bars, point bars, and straight stretches — as well as the distance of the sample sites from the river banks also appear to be local factors influencing the concentration of quartzite in the gravels, but the only consistent observation from the six pairs of samples from the same general locality, for which data are given in Table 1, is that samples from straight stretches are higher in quartzite than those from other locations.

Another factor which locally lowers the concentration of quartzite in the gravels is the presence of pebbles of sandstone, siltstone, and ironstone derived from Cretaceous and Tertiary strata into which the rivers have cut their valleys across the plains. Samples from sites close to cliffs of Cretaceous or Tertiary strata contain more pieces of sandstone

Table 1. Percentages of Quartzite in Samples of River Gravels

	Per Cent Gravel[1]	Per Cent Quartzite[2]	Per Cent Quartzite[3]	Size Cobble[4]
Athabasca 491	60.1	51.3	85.4	n.d.
Athabasca 576	76.5	73.9	96.6	n.d.
Athabasca 634	99.4	93.9	94.5	n.d.
Athabasca 808	80.1	66.3	82.8	n.d.
Bow 157	78.4	50.4	64.3	171
Bow 210	83.6	49.1	58.7	203
Little Smoky 160	69.8	55.8	79.9	213
McLeod 1	86.9	76.3	87.8	225
McLeod 65	84.3	67.5	80.1	188
McLeod 135	78.9	65.8	83.4	87
McLeod 147	87.1	77.1	88.5	267
North Sask. 182	65.7	53.5	81.4	112
North Sask. 196	64.8	51.1	78.9	138
North Sask. 216	62.4	51.1	81.9	125
North Sask. 236	71.5	62.8	87.8	64
North Sask. 237	70.0	60.8	86.9	146
North Sask. 253A	77.9	64.2	82.4	200
North Sask. 253	77.5	69.6	89.8	125
North Sask. 275	76.2	71.0	93.2	131
North Sask. 276	86.6	80.3	92.7	109
North Sask. 304	76.6	69.0	90.1	157
North Sask. 305	81.3	74.9	92.1	187
North Sask. 322	83.6	75.1	89.8	258
North Sask. 358	80.1	65.0	81.1	242
Oldman 100	76.8	47.6	62.0	189
Peace 538	72.2	46.9	65.0	n.d.
Peace 539	76.6	57.2	74.7	n.d.
Peace 604	80.2	53.6	66.8	n.d.
Peace 667	70.9	38.2	53.9	n.d.
Red Deer 233	67.7	51.1	75.5	129
Red Deer 260	77.5	58.5	75.5	162
Red Deer 290	77.2	63.0	81.6	181
Red Deer 290A	80.8	65.2	80.7	195
Red Deer 309	91.6	74.0	80.8	168
Red Deer 328	82.7	61.3	74.1	101
Smoky 3	80.4	63.7	79.2	181
Smoky 12	84.4	73.2	86.7	234
Smoky 93	72.5	60.6	83.6	136
Smoky 130	86.2	76.3	88.5	237
Smoky 168	89.6	73.8	82.4	n.d.
Smoky 209	93.1	82.2	88.3	315
South Sask. 122	61.6	40.8	66.2	106
Wapiti 1	74.1	59.6	80.4	212
Wapiti 20	76.0	66.0	86.8	205
Wapiti 42	83.5	72.0	86.2	246

[1] Weight per cent of sample in size fraction greater than 8 millimetres

[2] Weight per cent of quartzite greater than 8 millimetres in whole sample

[3] Weight per cent of quartzite in part of sample greater than 8 millimetres

[4] Nominal diameter of largest cobble in millimetres. The nominal diameter is the diameter of the sphere of equal volume; it was calculated from measured weights and 21 measurements of bulk density with a mean of 2.637g/cc, a standard deviation of 0.039 and a range of 2.48 to 2.68

and siltstone of various sizes and shapes than other samples.

It might be expected that in stretches where the present-day rivers are flowing in preglacial valleys or where they cross preglacial valleys, higher concentrations of quartzites would be found. Insufficient samples have been collected and analyzed to draw a firm conclusion, but some support for this expectation is obtained from the locations of the samples with the highest concentrations of quartzite. However, the concentrations of quartzite at these locations, along the Athabasca and North Saskatchewan Rivers (Fig. 1), may be due to the fact that greater thicknesses of quartzite formations are exposed in the mountains to the west of them in the Jasper-Sunwapta area than elsewhere (North, 1964).

Higher concentrations of quartzites are present in the gravels where the valleys of the present-day rivers contain a type of gravelly glacial material which is apparently the result of slumping of till or other glacial deposits into the river valleys. Most such places are of local extent, and the gravels in them appear coarser and contain more silt and clay than those in adjacent places.

COMPOSITION OF HIGHLY QUARTZITIC GRAVELS

Description of Quartzite Pebbles

The quartzite pebbles have a range of colors including white, pink, buff, brown, dark brown, dark grey, and light purple. Some are banded. Most are well rounded except where the gravel contains a sizeable proportion of glacial material which has received only limited alluvial transport. Most are fine grained, but some range to medium and coarse grained. Many consist of a tight mosaic of angular and irregular grains. Some grains are quartz which show a line of fine inclusions which mark the boundary between the original detrital grains and an overgrowth. Some quartz grains are cracked, and many show strain shadows. Other grains resembling quartz show somewhat indistinct roughly parallel marks caused by lines of inclusions, and other markings resembling perthite. The alumina content of the quartzites supports the conclusion that these grains are feldspar. Inclusions of blocky rutile, euhedral biotite, and green needles are present in some grains. Grain boundaries are marked by slightly brownish material, by distinct grains of goethite, and some by white mica. In a few places there is a small amount of interstitial calcite. These observations indicate that if the quartzite pebbles themselves are crushed, the resulting material cannot be readily beneficiated to yield a product with fewer impurities.

Size Analyses and Concentrations of Quartzite

Size analyses and concentrations of quartzite for numbered locations shown in Figure 1 are given in Appendix II (summarized in Table 1) and illustrated in Figure 2 (a,b, and c). Forty out of 45 samples in Figure 2 show the bimodal size distribution typical of alluvial gravels, with one mode in the pebble or cobble size range and one in the sand size range. Five samples have an extra mode in the pebble size range. Lithologic analyses show that in three of these — Bow 210, North Saskatchewan 322, and Red Deer 260 — the quartzite has only one mode in the cobble and pebble size ranges, the other mode being due to pebbles of different lithologies with their own size distributions. In the remaining two, North Saskatchewan 196 and Red Deer 290A, the quartzite itself has two modes in the pebble and cobble size ranges. The reasons for this are uncertain but may be due to admixture of significant quantities of preglacial gravel with a different size distribution in North Saskatchewan 196. This sample was collected where the present valley of the North Saskatchewan River coincides with the Beverly Valley, the preglacial valley of the North Saskatchewan at Edmonton (Carlson, 1967). For gravel samples from some locations where the alluvial gravel apparently has not been thoroughly mixed with slumped glacial material, size and lithological analyses show more than one mode in the pebble and cobble size ranges for lithological types such as granite and gneiss, limestone and dolomite, or quartzite. This may explain the two modes in Red Deer 290A.

In Table 1 the percentage of the sample greater than 8 millimetres is used as a convenient size parameter following the suggestion of Folk (1959, p. 49) for bimodal size distributions. This percentage increases as a river is ascended, indicating a coarsening of the gravel. This is particularly well shown by the North Saskatchewan and Red Deer Rivers, and to a lesser extent by the Smoky and Wapiti Rivers. The same increase is shown by the size of the largest quartzite cobbles, which is related to the amount of gravel in the sample (Fig. 3). Local variations in the upstream increase in the size parameters can be explained by the type of sample locations: upstream or downstream end of island or island bar, middle of point bar, and straight stretches, as well as the distance from riffles and the fact that the diameter of the largest cobbles is an extreme value. The correlation coefficient (r) between the percentage of gravel greater than 8 millimetres and the size of the largest cobbles is only 0.58, a value which reflects some of the above factors.

Of the samples listed in Table 1, the percentage of gravel in the size fractions greater than 8 millimetres exceeds 90 only in Athabasca 634 which has 99.4 per cent. This sample as revealed by the histogram (Fig. 2) is essentially an openwork gravel. Somewhat similar

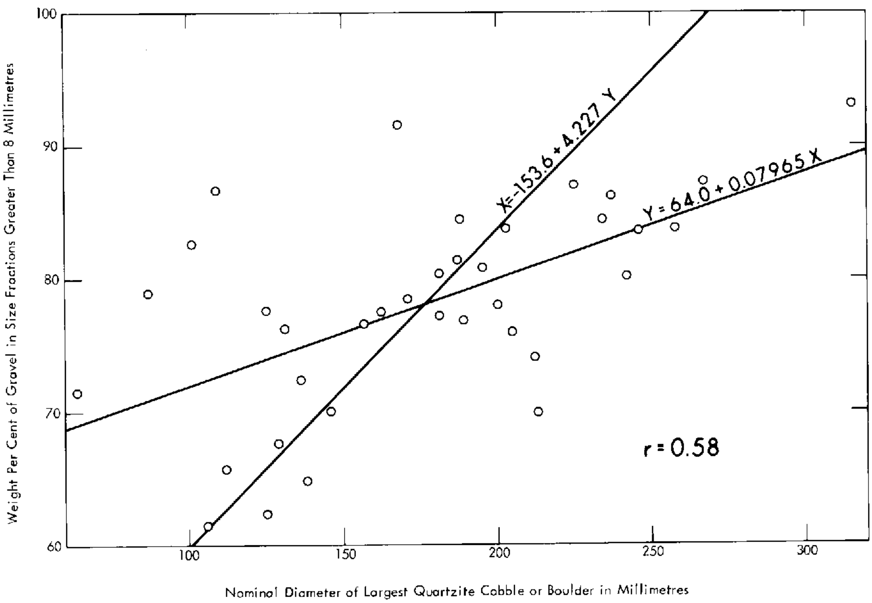

Figure 3. Scatter diagram of percentage of gravel coarser than 8 millimetres vs. size of largest quartzite cobble or boulder.

openwork gravels or gravels apparently originally deposited as openwork with interstices later filled with sand and silt, were encountered at three or four other places. Their relative scarcity suggests that special conditions are required for their formation and preservation in rivers (Pettijohn 1957, p. 245). One example of their formation was observed at the upstream end of an island bar on the Smoky River (Smoky 12) during a period of increasing flow. The elevation of the surface of the water was one or two feet lower on one side of the bar than the other near its upstream end. As the water rose it cut several new small channels across the upper end of the bar. The channels were up to several feet wide with banks of one to two feet that were being actively eroded by the rising water. The water in turn carried away all material smaller than medium-sized pebbles, leaving the larger pebbles after displacing them from the bank in the bed of the channel as an openwork gravel. North Saskatchewan 276 also is considered to have been deposited as an openwork gravel, the interstices later being filled with fine sand.

In Table 1 the concentration of quartzite is expressed (1) as the per cent of quartzite cobbles and pebbles greater than 8 millimetres in the bulk sample and (2) as the per cent of quartzite cobbles and pebbles in the fraction of the sample greater than 8 millimetres. The samples included in Table 1 and Figure 2 are all those having 75 per cent or more quartzite according to the second method of expressing quartzite concentrations, and a few others to give at least some coverage of most of the rivers in which gravels were sampled. The 75 per cent limit corresponds fairly closely to a 50 per cent limit according to the first method but does omit a few samples containing slightly more than 50 per cent quartzite. The second method also has been used for the quartzite concentrations shown in Figure 1. According to the first method, the concentration of quartzite is greater than 75 per cent in Athabasca 634, McLeod 1 and 147, North Saskatchewan 276 and 322, and Smoky 130 and 209. The second method of expressing quartzite concentration is a useful one if the gravel is screened. According to it, the concentration of quartzite is greater than 90 per cent in Athabasca 576 and 634, and North Saskatchewan 275 and 305.

For most samples in Table 1 and Figure 2, the percentage of quartzite in the size fraction between 4 and 8 millimetres is given: it decreases considerably in these finer size fractions. The quartzite pebbles in this size class appear more impure than those in the coarser classes.

The size of the largest quartzite cobble gives an indication of the maximum size of material that might be encountered in digging or dredging, although material somewhat larger than that listed in Table 1 is to be expected at the various sample locations or between them.

Chemical Composition

Representative parts of the size fractions between 8 and 32 millimetres of the gravel and of quartzite pebbles were selected from some of the samples in Table 1 for partial chemical analyses. The results are given in Table 2. Complete chemical analyses for major constituents of several boulders of quartzite from a gravel pit composed of glacial gravel and a sample split from several thousand pounds of crushed quartzite boulders selected for another purpose are given in Table 3. The correlation between the percentages of quartzite and silica in the analyzed samples is shown in Figure 4; the correlation coefficient (r) is 0.74.

The silica contents of the quartzites are more than 95 per cent for fairly long stretches of the Athabasca, McLeod, North Saskatchewan, Peace, Smoky, and Wapiti Rivers. The analyses of quartzite in Table 3 are similar to the purer quartzite analyses in Table 2, and even to some of the gravel analyses, such as Athabasca 491, 576, and 634, North Saskatchewan 237, Smoky 3, and Wapiti 20. These samples are among those with the higher quartzite contents. These chemical analyses indicate that quartzite from some places in the Athabasca, Little Smoky, McLeod, North Saskatchewan, Peace, Red Deer, Smoky, and Wapiti Rivers is suitable for use as a smelter flux, and for the manufacture of ferrosilicon and silica brick.

Table 2. Partial Chemical Analyses of Pebbles between 8 and 32 millimetres from Alluvial Gravels in Alberta, and of Quartzite Pebbles from the same Gravels

	Athabasca 491		Athabasca 576		Athabasca 634		Bow 210		Little Smoky 160		McLeod 1		McLeod 135	
	Gr[1]	Qu[2]	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
SiO_2	96.97	98.00	96.85	97.73	98.51	97.53	52.98	84.31	84.57	98.54	91.52	97.07	82.59	96.33
Al_2O_3	0.35	0.00	0.05	0.00	0.30	0.00	0.85	0.62	3.11	0.00	0.00	0.25	0.54	0.73
Fe_2O_3	0.44	0.38	0.35	0.23	0.23	0.47	0.69	0.45	0.91	0.25	0.58	0.30	0.84	0.57
MgO	0.33	0.12	0.23	0.23	0.18	0.23	5.92	2.42	1.32	0.22	0.59	0.25	0.80	0.34
CaO	0.52	0.28	0.13	0.18	0.25	0.27	18.11	4.37	4.23	0.34	2.54	0.56	7.01	4.26

	North Sask. 182		North Sask. 216		North Sask. 237		North Sask. 253A		North Sask. 253		North Sask. 322		Oldman 100	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
SiO_2	95.25	95.62	92.47	96.03	95.16	95.17	90.66	94.95	95.34	98.13	92.99	96.94	75.74	92.09
Al_2O_3	0.00	0.75	1.63	0.81	0.43	0.18	0.95	0.10	0.49	0.13	1.25	0.20	2.34	3.29
Fe_2O_3	0.65	0.79	0.84	0.63	0.68	0.63	0.68	0.55	0.72	0.29	0.61	0.36	0.98	0.18
MgO	0.34	0.25	0.47	0.26	0.22	0.58	0.72	0.50	0.54	0.25	0.48	0.21	3.37	0.66
CaO	1.51	1.82	1.57	0.38	0.81	0.84	2.86	1.46	0.83	0.22	1.51	0.34	7.40	1.02

	Peace 538		Peace 539		Peace 604		Peace 667		Red Deer 290		Red Deer 290A		Red Deer 309	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
SiO_2	91.27	97.10	86.09	97.02	95.54	97.89	76.29	95.26	83.64	93.28	72.20	96.25	78.33	n.d.
Al_2O_3	1.47	0.02	4.85	0.48	0.23	0.17	5.19	0.91	3.00	1.00	1.86	0.46	1.06	n.d.
Fe_2O_3	1.68	0.42	2.37	0.71	0.65	0.43	2.34	0.78	1.33	0.45	1.04	0.34	0.79	n.d.
MgO	0.66	0.25	1.32	0.22	0.36	0.25	1.18	0.44	1.73	0.66	3.74	0.39	1.89	n.d.
CaO	2.37	0.39	2.41	0.22	1.67	0.36	7.82	1.00	4.26	0.87	8.90	0.88	8.64	n.d.

	Red Deer 328		Smoky 3		Smoky 93		Smoky 130		South Sask. 122		Wapiti 20		Wapiti 42	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
SiO_2	74.84	88.77	97.51	98.33	90.79	96.99	73.95	97.51	82.80	92.66	97.77	97.81	88.05	97.72
Al_2O_3	2.10	1.13	0.29	0.22	3.02	0.61	2.22	0.33	4.21	1.74	0.35	0.28	2.42	0.27
Fe_2O_3	1.39	0.55	0.40	0.38	1.18	0.42	0.81	0.28	1.77	0.70	0.21	0.33	0.63	0.25
MgO	3.41	1.73	0.25	0.17	0.72	0.25	4.35	0.28	1.24	0.88	0.26	0.21	0.85	0.22
CaO	7.65	2.79	0.20	0.17	1.04	0.21	7.46	0.22	3.87	1.29	0.36	0.28	3.14	0.19

[1] Gr indicates all lithologies in the gravels

[2] Qu indicates quartzite only

Analysts: D. Benkie and H. Oikawa, Research Council of Alberta

EXPLOITATION

Although an investigation of processing these gravels for the production of industrial quartzite is beyond the scope of this report, a few comments are included. After digging the gravel from a terrace or dredging it from the river, washing and screening out the material finer than 8 millimetres (about one-half inch) will recover most of the quartzite in a size range for any subsequent treatment. The difference in elastic properties between quartzite and most of the other constituents makes the process known as elastic fractionation (Lenhart, 1960, p. 748) worth considering for such treatment. Sized and washed gravel is dropped onto an inclined steel plate. Harder and more durable pebbles such as quartzite bounce farther than softer limestone, dolomite, and sandstone, into a more distant bin. A middling product can be reprocessed. Crushing and screening to size specifications follow. The closeness in the bulk densities of quartzite, limestone, and dolomite appears to eliminate heavy media separation techniques from consideration, although these procedures might be suitable for removing ironstone.

Currently in Alberta, the rights to gravel deposits are held by the owners of the surface of the land. The provincial regulations for gravel deposits on land held by the Crown, including those in the beds of rivers, are administered by the Alberta Department of Lands and Forests.

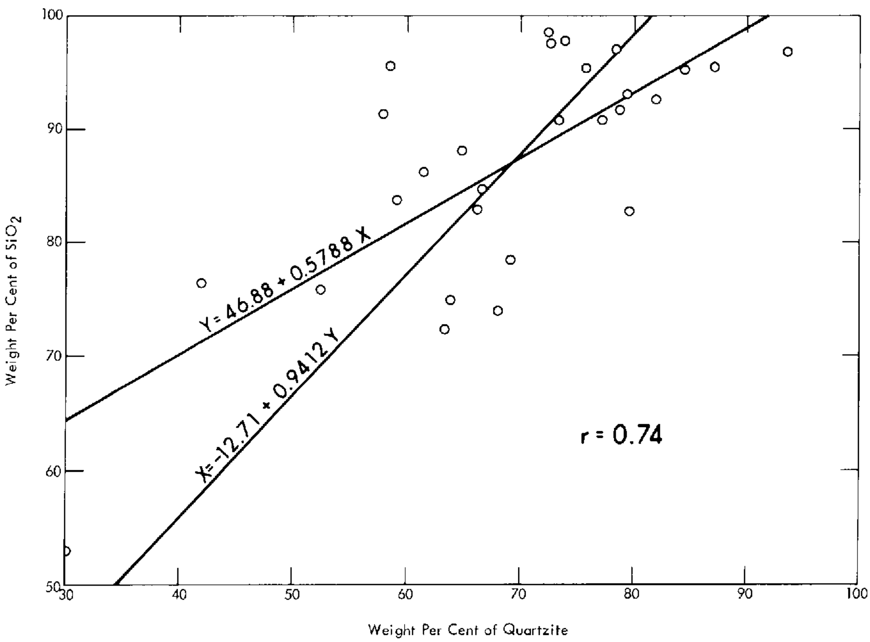

Figure 4. Scatter diagram of percentage of SiO_2 vs. percentage of quartzite in the 8 to 32 millimetre size fractions of some alluvial gravels.

Table 3. Chemical Analyses of Quartzite Boulders

	1	2	4	5	6	12	Quartzite
SiO_2	98.16	98.18	98.21	97.98	97.36	97.98	96.70
TiO_2	0.02	0.07	0.06	0.05	0.04	0.08	0.06
Al_2O_3	0.52	0.58	0.29	0.54	0.55	0.48	1.33
Fe_2O_3*	0.14	0.05	0.12	0.07	0.48	0.08	0.16
MgO	0.19	0.25	0.26	0.22	0.52	0.23	0.18
CaO	0.31	0.11	0.10	0.07	0.08	0.14	0.17
Na_2O	0.16	0.04	0.03	0.01	0.02	0.03	0.14
K_2O	0.07	0.13	0.08	0.20	0.06	0.13	0.55
P_2O_5	0.09	0.01	0.01	0.01	0.02	0.03	0.03
H_2O^+	0.23	0.19	0.10	0.20	0.28	0.17	0.23
H_2O^-	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Total iron as Fe_2O_3

Analyst: H. A. Wagenbauer

CONCLUSIONS

Analyses of samples of gravel from most of the major rivers in Alberta have shown that high percentages of quartzite are present as pebbles and cobbles in some alluvial gravels. The highest percentages were found in gravels in long stretches of the North Saskatchewan and Athabasca Rivers east of the Foothills in the western part of the Plains. These quartzites are derived from Lower Paleozoic quartzite formations in the Rocky Mountains. Factors governing their concentration in the rivers include the sources of the various constituents in the river gravels and their relative resistance to abrasion. The coarser fractions of the quartzites in some of these gravels, and even the unsorted pebbles and cobbles of the gravels themselves, have chemical compositions suitable for smelter flux and the manufacture of ferrosilicon and silica brick. It is unlikely that they can be economically beneficiated for uses requiring higher grade silica.

REFERENCES CITED

Carlson, V. A. (1967): Bedrock topography and surficial aquifers of the Edmonton district, Alberta; Res. Coun. Alberta Rept. 66-3, 21 pages.

Farvolden, R. N. (1963): Redrock channels of southern Alberta; Res. Coun. Alberta Bull. 12, p. 63-75.

Folk, R. L. (1959): Petrology of Sedimentary Rocks. Hemphills, Austin, Texas, 154 pages.

Gabert, G. M. and M. A. Roed (1968): Bedrock topography and surficial aquifers, Edson area, Alberta; Res. Coun. Alberta Rept. 68-1, 9 pages.

Geiger, K. W. (1965): Bedrock topography of southwestern Alberta; Res. Coun. Alberta Prelim. Rept. 65-1, 14 pages.

Gravenor, C. P. and L. A. Bayrock (1961): Glacial deposits of Alberta in Soils in Canada. Edited by R. F. Legget. Roy. Soc. Can., Spec. Publ. No. 3, p. 33-50.

Hewitt, D. F. (1951): Silica in Ontario, Ind. Min. Circ. No. 2, Ontario Dept. of Mines, 16 pages.

Lenhart, W. B. (1960): Sand and Gravel in Industrial Minerals and Rocks. Edited by J. L. Gillson, p. 733-758.

North, F. K. (1964): Cambrian, Part II – Cordillera in Geological History of Western Canada. Edited by R. G. McCrossan and R. P. Glaister, Alberta Soc. Petrol. Geol., p. 28-33.

Pettijohn, F. J. (1957): Sedimentary Rocks, Harper & Brothers, New York, 718 pages.

Stalker, A. MacS. (1961): Buried valleys in central and southern Alberta. Geol. Surv. Can. Paper 60-32.

________________ (1968): Identification of Saskatchewan gravels and sands. Can. Jour. Earth Sci., v. 5, p. 155-163.

APPENDIX I.

LOCATIONS OF SAMPLES

River and Number	Lsd.	Sec.	Tp.	R.	West of Mer.	Details of Location
Athabasca 491	8	22	71	1	5	Right bank 50 feet upstream from first lower pier of railway bridge at foot of bank.
Athabasca 576	9	31	61	5	5	Left bank on point bar about half way between right and left banks, about 300 feet downstream from abandoned ferry at Holmes Crossing.
Athabasca 634	3	3	60	12	5	River bed about 100 feet from right bank, about 150 feet downstream from highway bridge.
Athabasca 808	7	27	45	1	6	Right side of island bar near left bank, 150 feet from left bank, about 500 feet upstream from bridge.
Bow 157	15	17	21	23	4	Point bar about 50 feet from beginning of vegetation and about 200 feet from bushes on left bank.
Bow 210	9	8	22	29	4	Point bar (or head of island at high water) about 100 feet from left bank.
Little Smoky 160	1	25	66	22	5	Upstream end of island bar about 50 feet from right bank, and about 400 feet upstream from bridge.
McLeod 1	5	35	59	12	5	River bed about 125 feet from left bank, and about one-quarter mile downstream from bridge.
McLeod 65	14	33	54	14	5	Point bar about 200 feet from left bank, and about one-quarter mile downstream from bridge.

McLeod 135	12	14	52	19	5	Point bar about 30 feet from left bank at upstream end of riffle.
McLeod 147	14	27	52	20	5	Left side of island bar about 75 feet downstream from upstream end. Bar is about 250 feet long in middle of river.
North Sask. 182	12	14	55	22	4	Point bar about 60 feet from left bank.
North Sask. 196	10	34	53	23	4	River bed just downstream from prominent meander bend, 175 feet from left bank and about 1000 feet upstream from head of island near left bank.
North Sask. 216	10	24	52	25	4	Middle of left side of island bar in middle of river.
North Sask. 236	7	3	51	26	4	River bed about 30 feet from left bank and about 500 feet downstream from bridge.
North Sask. 237	13	33	50	26	4	Right side of island bar near left bank about 200 feet from left bank and about 1000 feet upstream from bridge.
North Sask. 253A	15	27	50	1	5	Point bar 400 feet from right bank and about 1000 feet downstream from former Holborn ferry. Left bank here is a high cliff of bedrock.
North Sask. 253	13	27	50	1	5	River bed about 75 feet from left bank and about 500 feet upstream from former Holborn ferry.
North Sask. 275	1	21	51	3	5	Right side of island near left bank about 75 feet upstream from its upstream end and 330 feet from left bank.
North Sask. 276	4	15	51	3	5	Point bar about 150 feet from left bank and 500 feet downstream from former Genesee ferry.
North Sask. 304	12	13	50	6	5	River bed about 300 feet from left bank and about 900 feet downstream from Berrymoor ferry.

Locations of Samples

River and Number	Lsd.	Sec.	Tp.	R.	West of Mer.	Details of Location
North Sask. 305	8	14	50	6	5	Left side of island bar near right bank and about 150 feet from right bank and about 500 feet upstream from Berrymoor ferry.
North Sask. 322	13	35	48	7	5	Right side of island bar near left bank and about 400 feet from left bank about one mile upstream from highway bridge.
North Sask. 358	11	13	45	9	5	Point bar about 400 feet from treeline on right bank.
Oldman 100	13	1	9	22	4	River bed about 250 feet from left bank, and about 450 feet downstream from piers that carry power lines downstream from highway bridge.
Peace 538	3	16	82	23	5	River bed on right side of upstream end of island near left bank.
Peace 539	9	8	82	23	5	River bed about 100 feet from right bank.
Peace 604	11	20	81	6	6	River bed on middle of left side of island near right bank.
Peace 667	10	27	82	13	6	River bed about 100 feet from left bank.
Red Deer 233	1	3	35	21	4	About 100 feet from left side of island in middle of river near upstream end of island.
Red Deer 260	4	34	38	22	4	River bed about 75 feet from left bank and about 600 feet downstream from bridge.
Red Deer 290	11	13	38	26	4	River bed about 200 feet from right bank and about 300 feet downstream from bridge.

Red Deer 290A	13	13	38	26	4	Right side of upstream end of island bar about 150 feet from left bank.
Red Deer 309	16	33	38	27	4	Point bar about 150 feet from left bank.
Red Deer 328	7	5	37	28	4	Upstream end of right side of island bar about 100 feet from left bank.
Smoky 3	4	1	83	22	5	Right side of island bar in middle of river.
Smoky 12	2	1	82	23	5	Upstream end of left side of island bar in middle of river.
Smoky 93	11	1	75	2	6	Point bar about 150 feet from left bank.
Smoky 130	2	7	71	2	6	Upstream end of left side of island in middle of river.
Smoky 168	7	31	67	4	6	Upstream end of right side of island near left bank.
Smoky 209	15	30	63	2	6	River bed about 200 feet from right bank and about 200 feet upstream from small creek.
South Sask. 122	12	35	12	6	4	Upstream end of right side of island bar near left bank.
Wapiti 1	6	13	71	3	6	Point bar about 60 feet from right bank.
Wapiti 20	11	14	70	5	6	River bed 60 feet from left bank, and about 1000 feet downstream from mouth of Big Mountain Creek.
Wapiti 42	7	11	70	8	6	Right side of island bar about 300 feet from left bank.

APPENDIX II.

SIZE DISTRIBUTION AND QUARTZITE CONTENT OF SOME ALLUVIAL GRAVELS IN ALBERTA

(calculated by weight per cent)

Size retained (mm)	Athabasca 491		Athabasca 576		Athabasca 634		Athabasca 808		Bow 157		Bow 210		Little Smoky 160		McLeod 1	
	Gr[1]	Qu[2]	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
128	-*	-	-	-	-	-	9.8	9.0	-	-	13.3	13.3	-	-	11.1	7.3
64	3.2	2.8	20.9	20.5	54.6	51.8	22.6	20.3	18.6	15.3	24.4	18.6	11.1	10.4	32.6	32.0
32	30.8	28.0	23.1	23.0	41.9	40.0	20.6	17.5	21.3	14.7	17.3	8.6	26.9	24.2	17.7	16.9
16	19.5	16.7	25.8	24.8	2.9	2.1	19.4	16.0	24.6	14.0	18.6	5.4	19.7	15.4	14.9	13.0
8	6.6	3.8	6.7	5.6	<0.1	<0.1	7.7	3.5	13.9	6.4	10.0	3.2	12.1	5.8	10.6	7.1
4	2.9	n.d.**	2.2	n.d.	<0.1	<0.1	5.0	1.8	6.1	2.2	4.9	1.6	6.2	2.2	2.5	1.2

Size retained (mm)	McLeod 65		McLeod 135		McLeod 147		North Sask. 182		North Sask. 196		North Sask. 216		North Sask. 236		North Sask. 237	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
128	2.7	2.7	-	-	21.0	18.4	-	-	-	-	-	-	-	-	-	-
64	37.7	35.8	3.4	3.4	27.9	27.4	10.8	10.0	16.8	15.0	0.5	0.5	-	-	1.9	1.9
32	16.3	13.7	16.4	15.3	17.5	15.9	16.9	14.7	14.5	12.8	9.8	7.9	16.3	14.8	22.4	20.3
16	14.7	9.4	39.9	33.8	13.7	11.3	20.8	17.4	20.7	15.4	30.3	26.6	38.8	35.1	28.3	25.8
8	12.9	5.9	19.2	13.3	7.0	4.1	17.2	11.4	12.8	7.9	21.8	16.1	16.4	12.9	17.4	12.8
4	3.7	1.1	4.7	2.6	3.2	2.0	8.1	2.8	5.8	2.2	6.9	2.7	3.8	1.6	6.6	2.8

Size retained (mm)	North Sask. 253A		North Sask. 253		North Sask. 275		North Sask. 276		North Sask. 304		North Sask. 305		North Sask. 322		North Sask. 358	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
128	2.4	2.4	-	-	-	-	-	-	-	-	4.0	4.0	9.6	9.6	7.5	7.5
64	16.9	14.7	5.3	5.2	10.1	10.1	7.2	7.2	13.1	12.6	25.4	24.9	31.2	29.6	30.4	26.6
32	24.8	22.3	13.4	13.2	15.0	14.6	30.5	30.2	21.7	20.4	29.4	27.3	16.6	15.1	16.8	14.6
16	20.2	15.4	36.6	33.9	40.4	37.8	35.8	32.9	27.9	25.4	15.3	13.5	17.2	14.7	15.4	11.1
8	13.6	9.4	22.2	17.3	10.7	8.5	13.1	10.0	13.9	10.6	7.2	5.2	9.0	6.1	10.0	5.2
4	4.8	2.4	6.2	3.4	1.3	0.9	2.0	1.1	2.0	1.0	1.6	0.9	2.8	1.6	4.3	2.0

Size retained (mm)	Oldman 100		Peace 538		Peace 539		Peace 604		Peace 667		Red Deer 233		Red Deer 260		Red Deer 290	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
128	3.8	3.8	4.8	3.0	-	-	-	-	-	-	-	-	-	-	13.2	13.2
64	16.7	11.9	12.2	8.5	24.9	21.0	16.1	11.0	3.2	2.0	6.9	4.3	27.7	23.2	30.3	27.7
32	25.2	15.6	23.1	16.8	23.7	19.0	38.3	27.5	41.0	25.0	22.4	20.0	17.4	14.5	12.2	9.4
16	20.6	11.5	16.8	11.8	16.9	11.0	22.2	13.5	26.5	11.0	25.1	19.6	18.8	13.0	12.1	7.7
8	10.5	4.8	15.3	6.8	11.1	6.2	3.6	1.6	0.2	0.2	13.3	7.2	13.6	7.8	9.4	5.0
4	5.8	2.1	8.3	3.7	5.1	2.4	0.6	0.2	<0.1	<0.1	6.4	2.0	5.8	2.1	4.3	1.5

[1]Gr indicates all lithologies in the gravel. [2]Qu indicates quartzite only.

* dashes indicate no material present in that size interval.
** n.d. indicates not determined.

Size Distribution and Quartzite Content of Some Alluvial Gravels in Alberta (cont'd.)

Size retained (mm)	Red Deer 290A		Red Deer 309		Red Deer 328		Smoky 3		Smoky 12		Smoky 93		Smoky 130		Smoky 168	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
128	6.6	6.6	-	-	-	-	-	-	5.3	5.3	-	-	8.3	8.3	25.4	23.7
64	36.0	32.4	22.7	20.7	9.5	8.2	13.7	10.7	29.2	27.8	5.5	5.5	36.9	34.4	27.3	24.7
32	10.7	8.8	32.0	27.8	29.6	25.3	32.7	28.3	24.1	20.4	22.1	20.5	24.1	22.1	18.5	14.3
16	15.7	11.4	27.8	20.1	31.2	21.9	26.3	21.2	18.6	14.7	35.8	30.2	10.5	8.0	12.4	8.3
8	11.8	6.0	9.1	5.4	12.4	5.9	7.7	3.5	7.2	5.0	9.1	4.4	6.4	3.5	6.0	2.8
4	6.1	2.5	1.3	0.5	3.2	1.4	2.9	1.0	<0.1	<0.1	4.2	1.0	1.3	0.6	2.8	1.1

Size retained (mm)	Smoky 209		South Sask. 122		Wapiti 1		Wapiti 20		Wapiti 42	
	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu	Gr	Qu
128	29.7	29.7	-	-	-	-	7.3	7.3	14.6	14.6
64	27.4	27.0	2.7	2.7	8.5	8.5	17.5	16.0	32.2	30.8
32	18.6	14.2	11.6	6.8	28.7	24.8	26.3	24.3	16.8	13.7
16	13.3	8.8	28.5	20.4	25.4	19.8	17.2	13.8	13.8	9.9
8	4.1	2.5	18.8	10.9	11.5	6.5	7.7	4.6	6.1	3.0
4	1.1	0.5	8.1	2.8	4.8	1.6	2.8	1.1	4.9	1.6

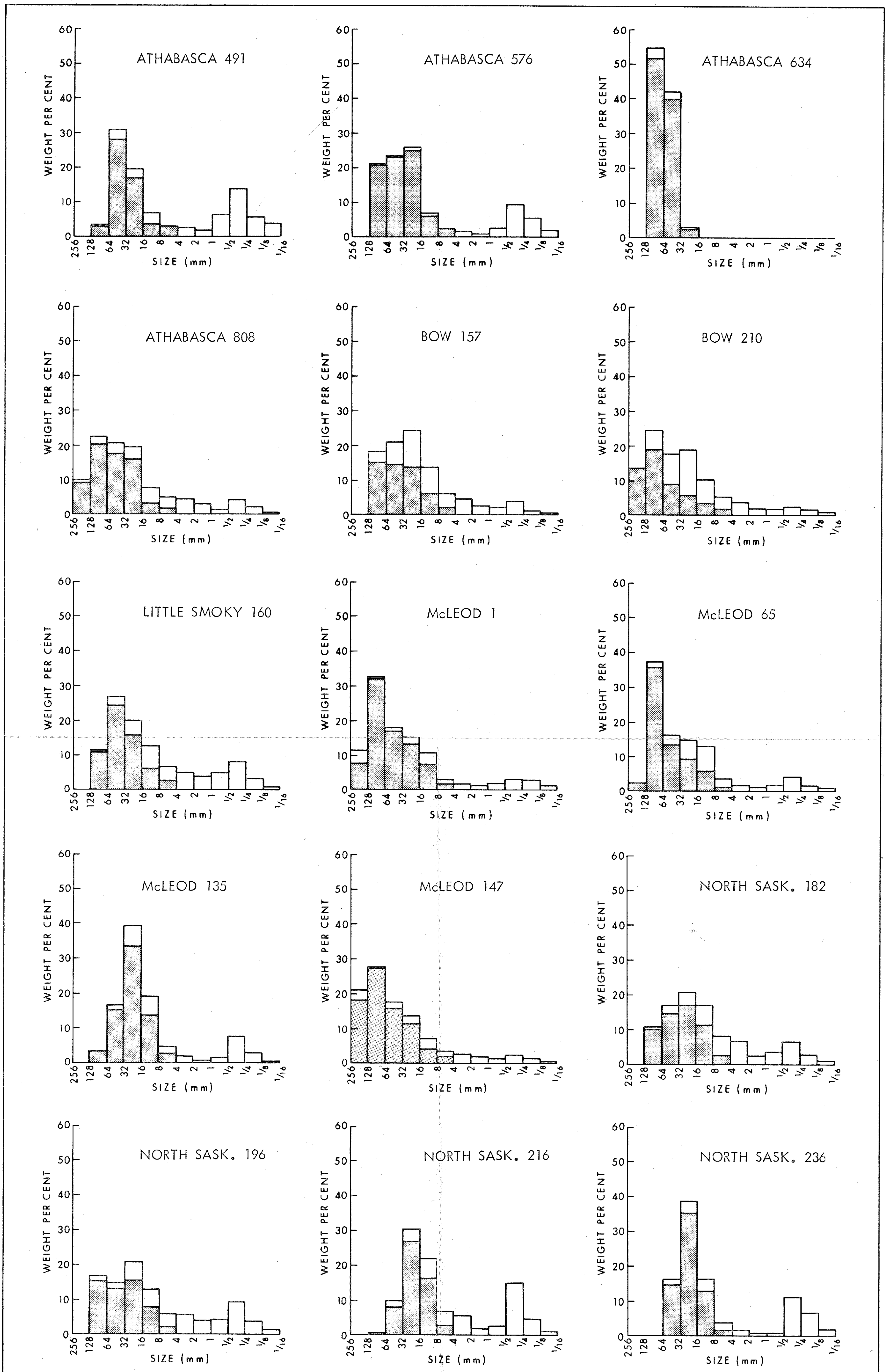

FIGURE 2a. SIZE DISTRIBUTIONS OF ALLUVIAL GRAVELS AND CONCENTRATIONS OF QUARTZITE (HATCHED) IN THE COARSER SIZE FRACTIONS.

To accompany RCA Report 69-2, by L.B. Halferdahl

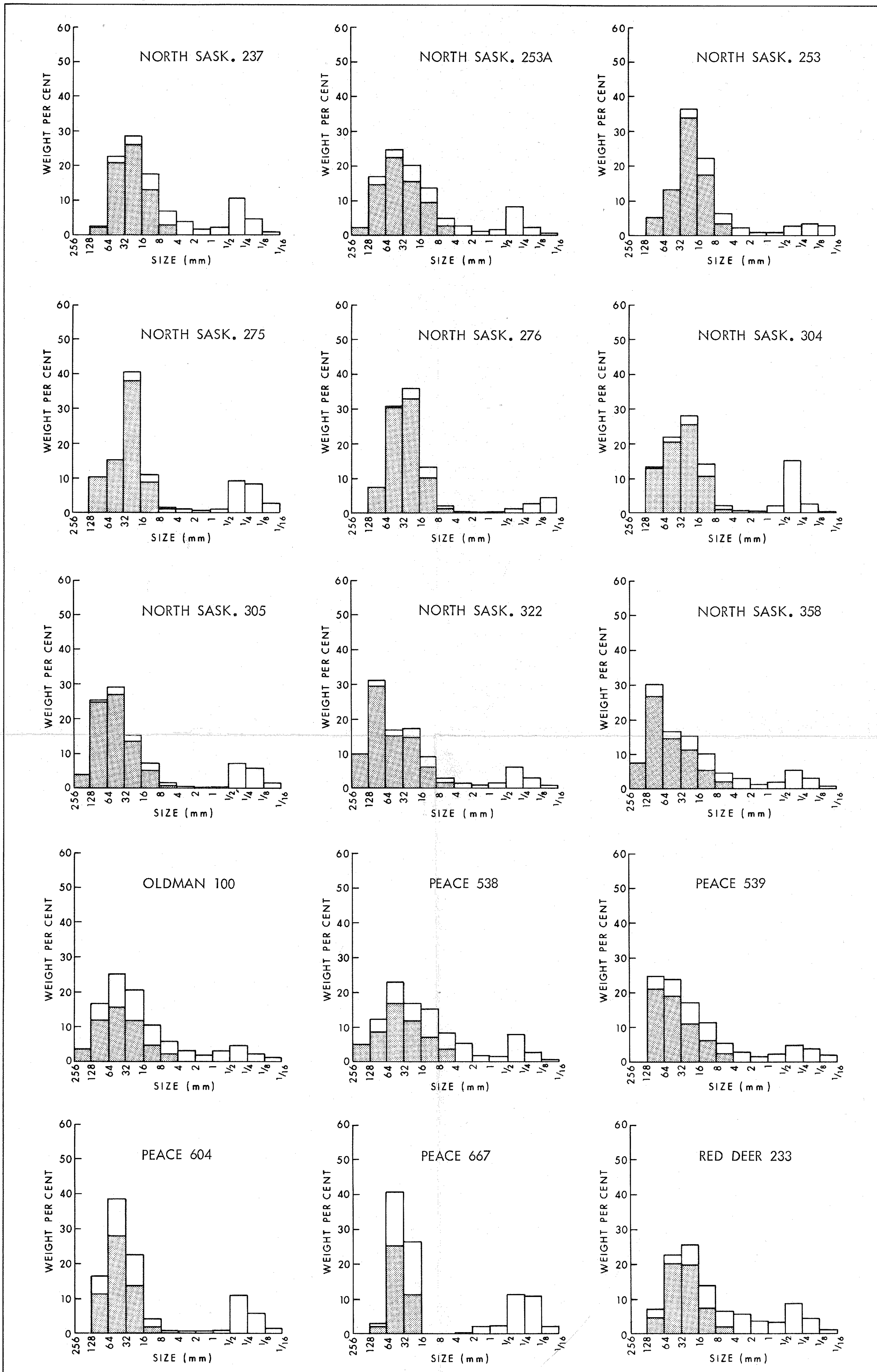

FIGURE 2b. SIZE DISTRIBUTIONS OF ALLUVIAL GRAVELS AND CONCENTRATIONS OF QUARTZITE (HATCHED) IN THE COARSER SIZE FRACTIONS.

To accompany RCA Report 69-2, by L.B. Halferdahl

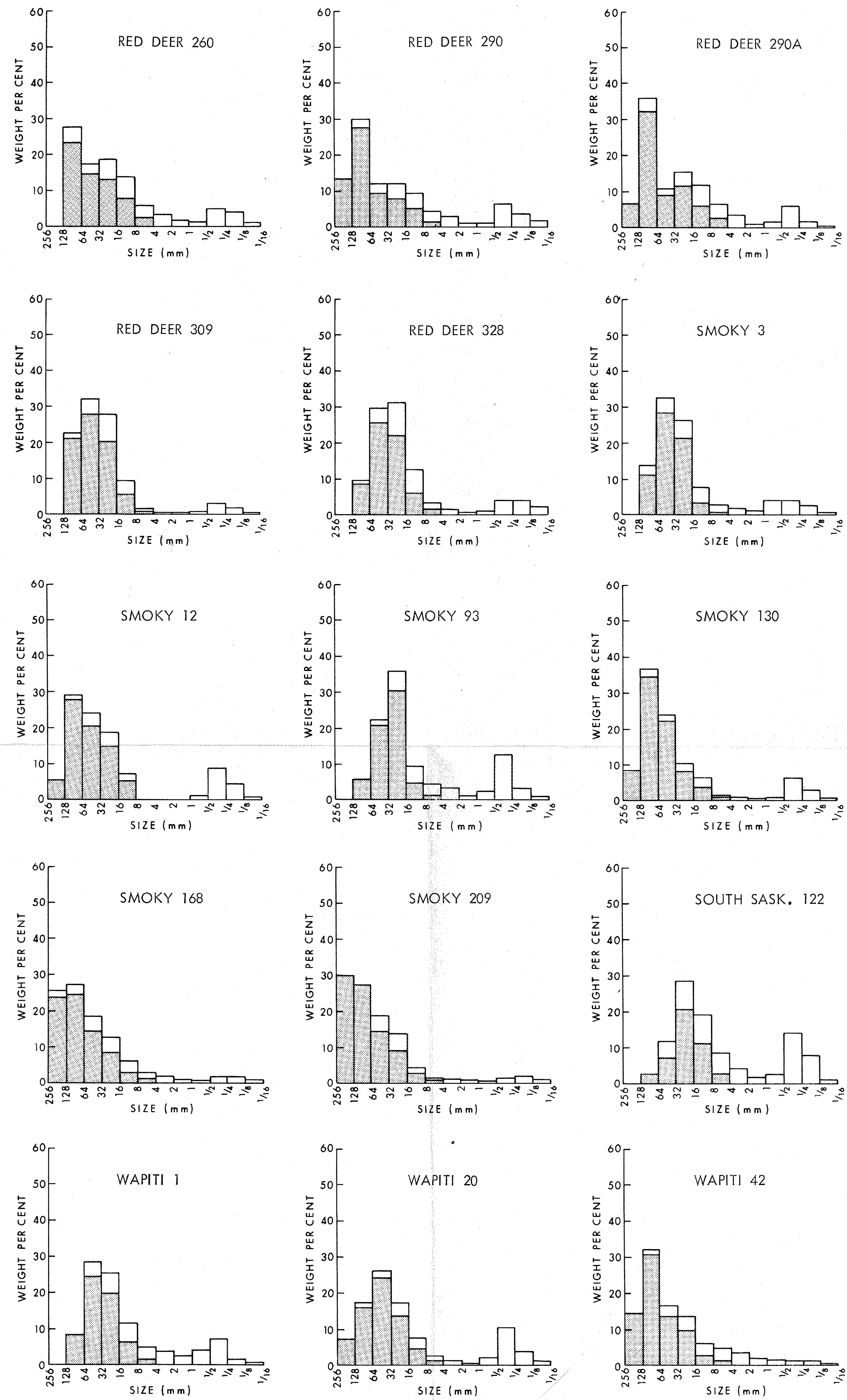

FIGURE 2c. SIZE DISTRIBUTIONS OF ALLUVIAL GRAVELS AND CONCENTRATIONS OF QUARTZITE (HATCHED) IN THE COARSER SIZE FRACTIONS.

To accompany RCA Report 69-2, by L.B. Halferdahl

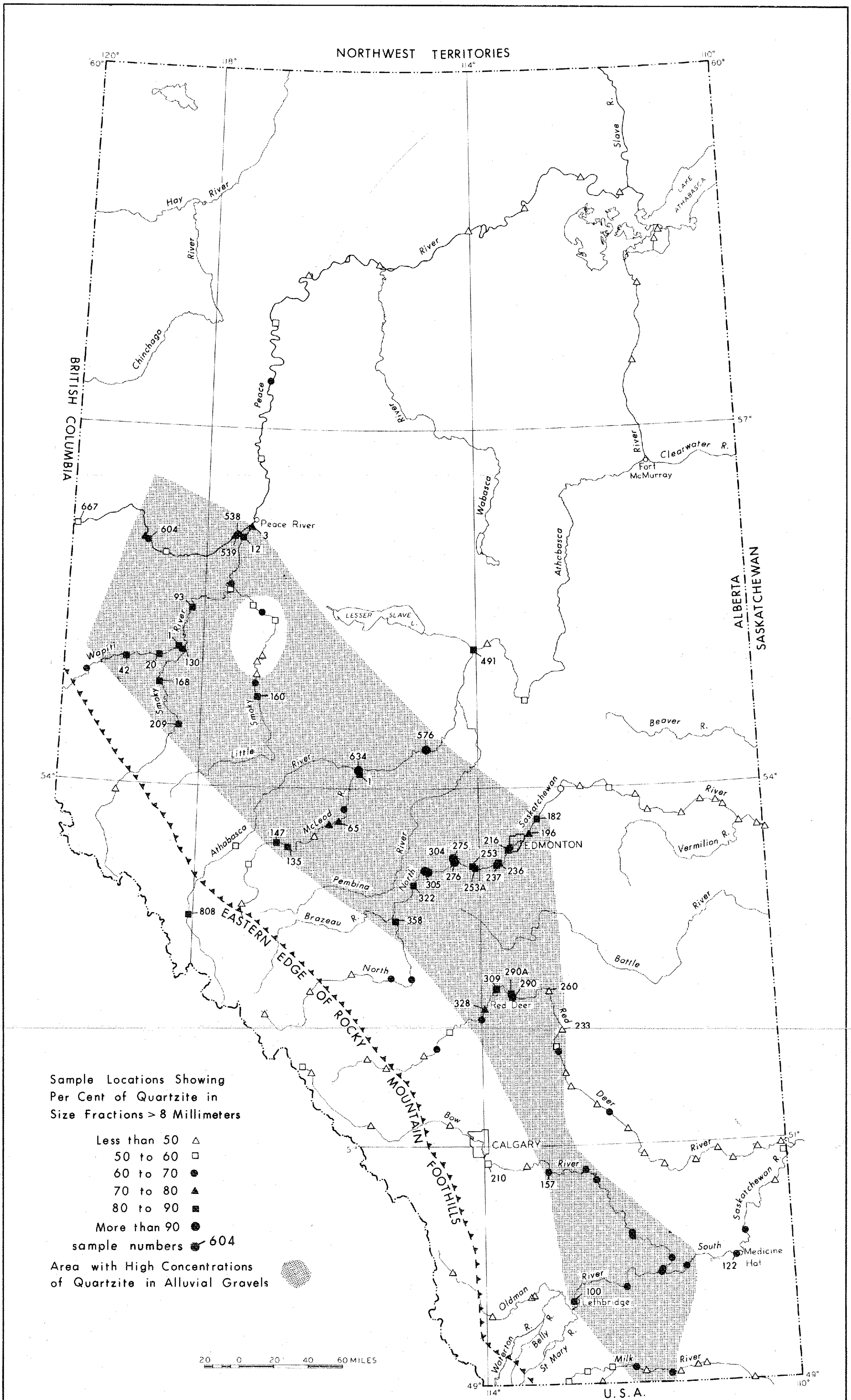

FIGURE 1. CONCENTRATIONS OF QUARTZITE IN SAMPLES OF GRAVEL AND SAND IN SOME RIVERS IN ALBERTA

To accompany RCA Report 69-2, by L.B. Halferdahl